AUG 07 1985

LA-UR -85-2551

CONF-850890--11

Los Alamos National Laboratory is operated by the University of California for the United States Department of Energy under contract W-7405-ENG-36

LA-UR--85-2551

DE85 015696

TITLE EVOLUTION OF THE STRUCTURAL PHASE TRANSITION IN CeAg IN THE LOW PRESSURE RANGE

AUTHOR(S) S. Horn, H. Borges, J. D. Thompson and R. D. Parks

SUBMITTED TO International Conference on Magnetism, San Francisco, CA, August 26-30, 1985.

Los Alamos Los Alamos National Laboratory Los Alamos, New Mexico 87545

FORM NO 836 R4
ST NO 2629 5/81

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

To be presented at the International Conference on
Magnetism, San Francisco, Aug. 26-30, 1985

Evolution of the Structural Phase Transition in CeAg in the Low Pressure Range

S. Horn* and H. Borges*
Department of Physics
Polytechnic Institute of New York, Brooklyn, NY 11201

and

J. D. Thompson
Los Alamos National Laboratory, Los Alamos, NM 87545

and

R. D. Parks*
Center for Materials Science
Los Alamos National Laboratory, Los Alamos, NM 87545

Abstract

Previous studies have suggested that the cooperative structural transition observed in CeAg near 15 K at ambient pressure evolves into the martensitic transition which is observed under applied pressure. By utilizing very small pressures, we have observed the birth of the martensitic transition and demonstrated that the two transitions are uncoupled.

Key words for subject index:
resistivity
pressure
structural phase transition

PACS Nos. 72.15.-v
64.70.-p

Further correspondence should be addressed to:

Dr. S. Horn
Physics Department
New York University
4 Washington Place
New York, NY 10003 212-598-3651

At ambient pressure the CsCl-structure compound CeAg undergoes a transition into a tetragonal state [1,2] at $T \simeq 15$ K, followed by a ferromagnetic transition at $T = 5$ K. This structural transition has been studied in the past by application of pressure to CeAg [3,4] as well as by alloying with In [5]. For Ce(Ag,In) and the related system La(Ag,In), a Jahn-Teller-like band splitting of narrow conduction bands near E_F was considered to cause the structural phase transition [6]. The temperature where this transition occurs varies strongly with the Indium concentration. From extrapolation to the pure CeAg no phase transition was expected at ambient pressure. Therefore, and since the isostructural compound LaAg remains cubic for all temperatures at ambient pressure, the structural transition in CeAg was attributed to a cooperative Jahn-Teller effect in the Γ_8 crystal field ground state of the Ce-ions [7].

Measurements [8] of the temperature-dependence of the elastic constants of La(Ag,In) and a CeAg single crystal suggested that the structural phase transition was driven by a softening of zone boundary phonons, and that the Cerium 4f-electrons were not involved in this transition. This point of view is supported by susceptibility measurements, which show no distinct anomaly near the transition T_m [8].

Resistivity measurements under pressure ($\geq$ 2.4 kbar) on CeAg showed a resistance anomaly which shifted to higher temperature with increasing pressure [3]. Although this anomaly is different from the one at zero pressure, in the sense that the resistivity increases rather than decreases and a hysteresis is observed, it was interpreted to be the same kind of phase transition [3].

In order to study the evolution of the phase transition(s) in CeAg, we have measured the resistance of a polycrystalline sample under very small hydrostatic pressures, down to P=0.25 kbar. We estimate the error in the absolute pressures as quoted to be 20% and in the relative pressure $\Delta P/P$ to be 10%. Details of the pressure clamp and other techniques used in the experiment are described elsewhere [9]. The sample was prepared by melting in an arc furnace and annealing at 650 C for 2 days under vacuum.

Figure 1 shows the resistance of CeAg in the temperature range 4 K to 80 K at five different pressures. At P=0 the sample shows the two well-known transitions, both indicated by a sharp drop in the resistivity. We find the transition temperature T_m for the structural transition, taken from the maximum of dR/dT (Fig. 2), to be T_m=16.5 K. For P=0.25 kbar, a flattening of the R versus T curve is observed around T≈24 K, followed by a sharp resistance drop at exactly the same temperature as at zero pressure. A small hysteretic effect is observed. Similar behavior is found for P=0.75 kbar but the onset of flattening has shifted to T=30 K. For P=2.4 kbar our data agree well with ref. [3]. The fact that T_m is independent of pressure is clearly seen from Fig. 2. Therefore for low pressures our data seem to indicate that two different resistance anomalies exist. The position of the first one, an increase of resistance with decreasing temperature, is strongly pressure dependent, while the position of the second one, a sharp drop of resistance, is pressure independent.

The origin of the two transitions is not clear. In addition to the zone boundary phonon softening, which is believed to drive the structural phase transition [8], magnetoelastic effects, i,e, strain coupling to localized 4f- electrons, might exist, as was found in $La_{.91}Ce_{.09}Ag$ [8]. Indication for strong quadrupolar effects were found from neutron scattering measurements [10]. Therefore one might expect a contribution of the Γ_8 state to the phase transition, though it might not be the driving force. In this case the drop of the resistivity at T=16.5 K could be attributed to a splitting of the Γ_8 state and an according decrease of magnetic exchange and quadrupolar scattering. It can be shown that even in a mean field approximation a splitting of the Γ_8 ground state does not necessarily lead to a pronounced anomaly in the magnetic susceptibility.

To summarize, at low pressures, P<1.3 kbar, the electrical resistance shows two anomalies, which behave quite differently with pressure. An unambiguous interpretation of these anomalies is not possible on the basis of the present data.

Acknowledgements

One of the authors (S.H.) gratefully acknowledges support by a scholarship from the Deutsche Forschungsgemeinschaft. H. Borges acknowledges support by a scholarship from C.N.P.q. The work performed at Polytechnic Institute of New York was supported by the National Science Foundation under Grant DMR- 8202726 and the work at Los Alamos was performed under the auspices of the Department of Energy.

References

*Present address: Department of Physics, New York University,
4 Washington Place, New York, NY 10003

[1] D.Schmitt, P.Morin and J.Pierre, J.Magn.Magn.Mat. 8 (1978) 249

[2] H.Ihrig and S.Methfessel, Z.Phys. B24 (1976) 381

[3] H.Kadomatsu, M.Kurisu and H.Fujiwara, Phys.Let. 70A (1979) 472

[4] A.Eiling and J.S.Schilling, Phys.Rev.Let. 46 (1981) 364

[5] H.Ihrig and M.Lohmann, J.Phys.F 7 (1977) 1957

[6] H.Ihrig and S.Methfessel, Z.Phys. B24 (1976) 385

[7] D.K.Ray and J.Sivardiere, Solid State Commun. 19 (1976) 1053

[8] R.Takke,N.Dolezal,W.Assmus and B.Luthi, J.Magn.Magn.Mat. 23 (1981) 247

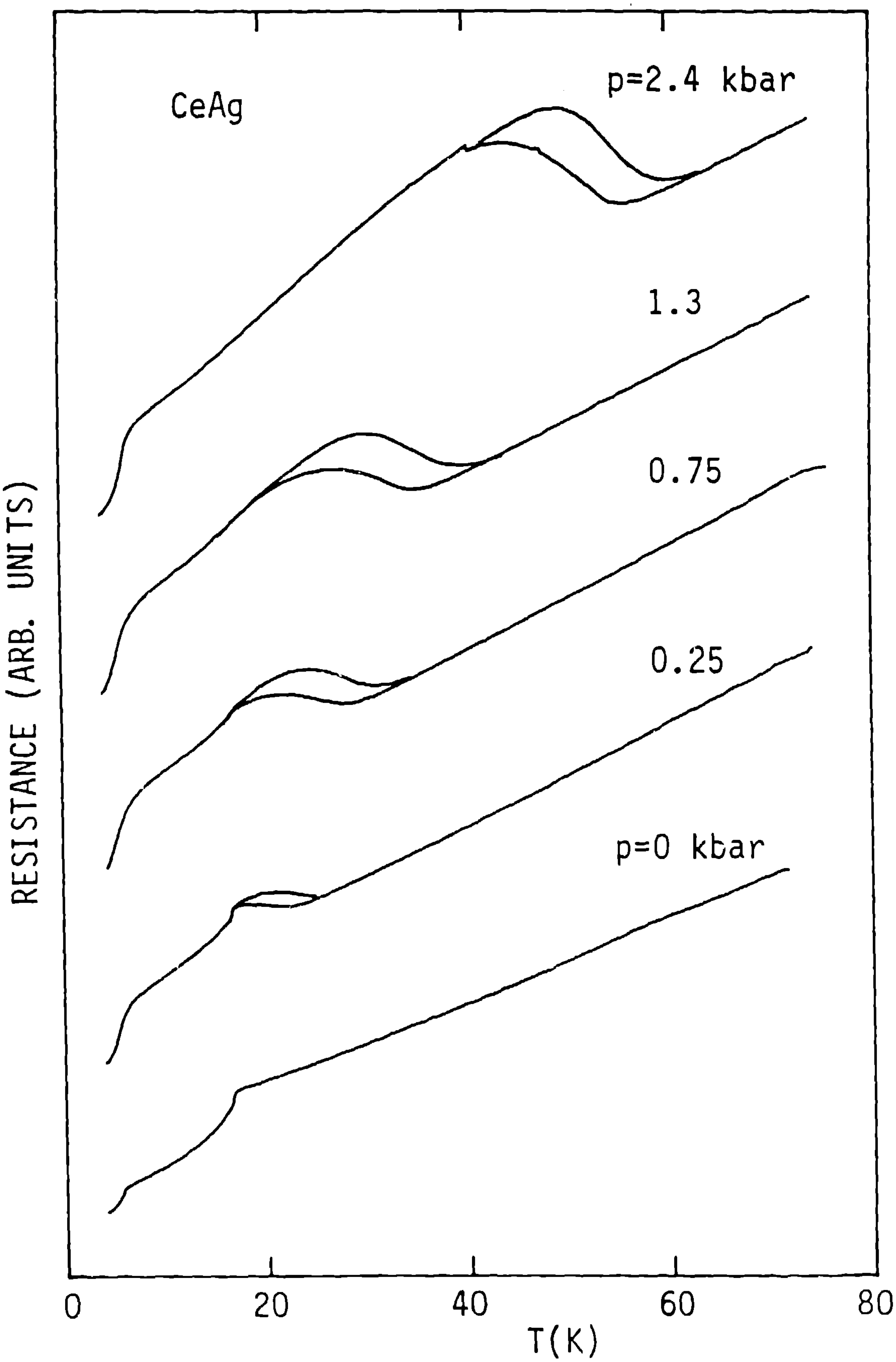
[9] J.D.Thompson, Rev.Sci.Instrum. 55 (1984) 231

[10] B.Frick, Thesis, Cologne 1984, unpublished

Figure Captions

Fig. 1. Temperature dependence of the resistance of CeAg for different pressures.

Fig. 2. Derivative of the resistance of CeAg with respect to temperature for different pressures.


CeAg
p=2.4 kbar
1.3
0.75
0.25
p=0 kbar
RESISTANCE (ARB. UNITS)
0
20
40
60
80
T(K)

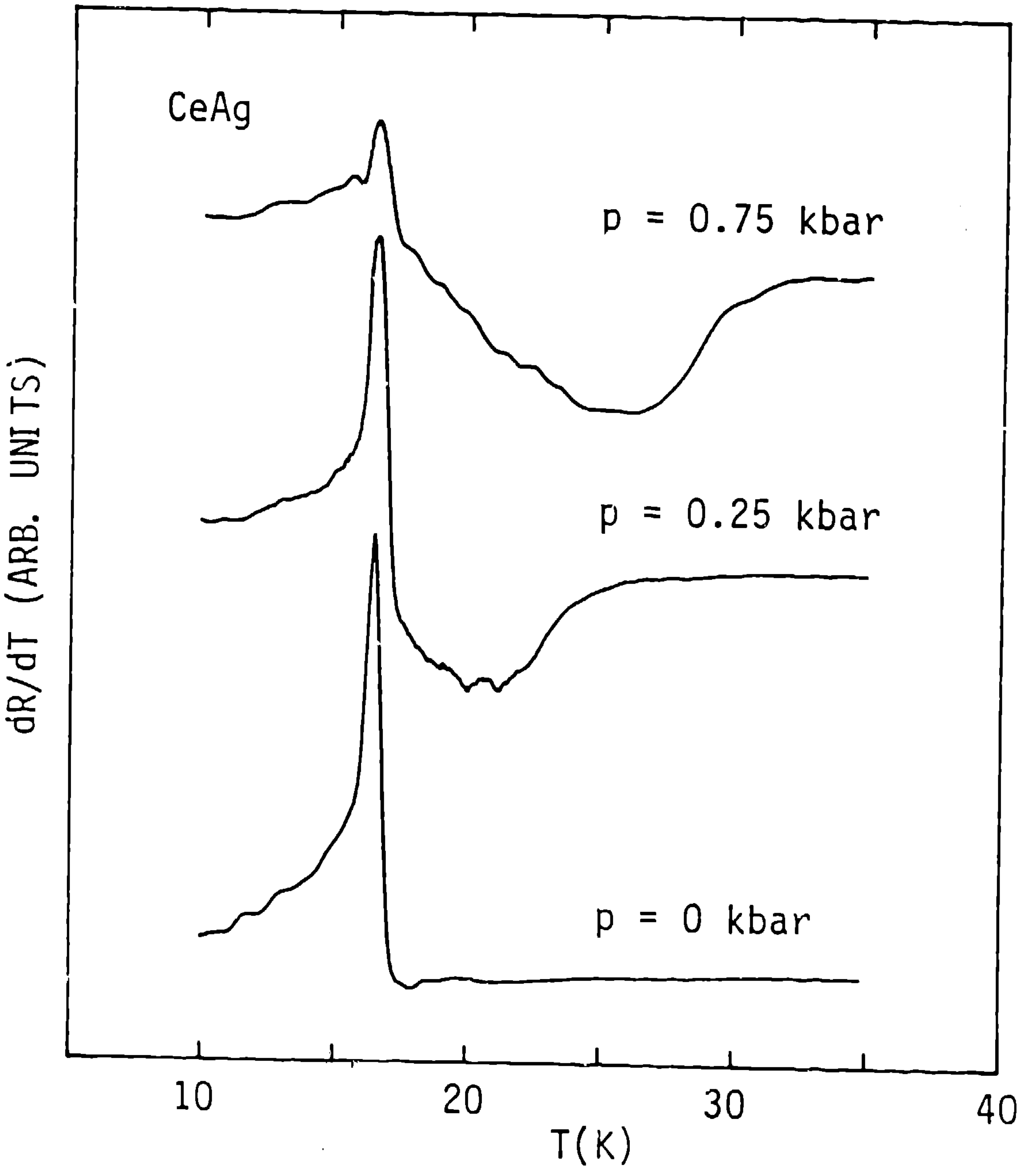


Fig. 2